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ABSTRACT

Using data collected from an undergraduate science methods class, this paper interrogates a variety of ways that preservice teachers construct their identities as both students of science and prospective teachers of science. Data sources included writings about an issue of "difference" in science class, a science autobiography, student-generated metaphors for teaching, a counternarrative to a personal experience, and a philosophy about teaching elementary school science. Drawing on these autobiographical writings about past experiences with science and the ways these inform visions of their future practice as teachers, this paper links the theoretical literature about science, gender, and schooling with the personal experiences of these students. Results from an analysis of the students' writings illustrate the incredible range of ways that school science was experienced in a gendered manner, and the ways in which these experiences shape these preservice teachers' orientations toward school science as they contemplate teaching. Their writings suggest the powerful effects that past science experiences have on their on-going construction of science teaching identities. Further, their writings recognize the complex ways in which the construct of schooling, gender, and science interact, hybridize, and experience synergy or attrition as they collide with one another. (Contains 42 references.) (Author/YDS)

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Teaching science/learning gender: Preservice elementary teachers write about science, gender, and identity

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Abstract

Using data collected from an undergraduate science methods class, this paper interrogates a variety of ways that preservice teachers construct their identities as both students of science and prospective teachers of science. Data sources included writings about an issue of "difference" in science class, a science autobiography, student-generated metaphors for teaching, a counternarrative to a personal experience, and a philosophy about teaching elementary school science. Drawing on these autobiographical writings about past experiences with science and the ways these inform visions of their future practice as teachers, this paper links the theoretical literature about science, gender, and schooling with the personal experiences of these students. Results from an analysis of the students' writings illustrate the incredible range of ways that school science was experienced in a gendered manner, and the ways in which these experiences shape these preservice teachers' orientations towards school science as they contemplate teaching. Their writings suggest the powerful effects that past science experiences have on their on-going construction of science teaching identities. Further, their writings recognize the complex ways in which the constructs of schooling, gender, and science interact, hybridize, and experience synergy or attrition as they collide with one another.

Introduction

Although an extensive research base exists about the gendered nature of science (Bryson & de Castell, 1994; Easlea, 1983; Harding, 1986, 1991; Keller, 1985, 1992; Merchant, 1980; Schiebinger, 1989, 1993; Spanier, 1995; Traweek, 1988), including school science (Brickhouse, 1994; Letts, 1997, 1998; McLaren & Gaskell, 1995), and an increasing research base is accruing about the ways that schooling is complicit in the constructions of certain kinds of gendered identities (Davies, 1989, 1993; Mac An Ghaill, 1994; Thorne, 1993), this paper seeks to examine the intersection of these research programs— namely how past experiences in science are "read" by preservice teachers as they construct science teaching identities. Work in this area is just starting to occur, as witnessed by some recent conference papers (Helms & Johnson, 1998; Richmond & Kurth, 1998; Smith & Anderson, 1998) and a recent spate of books (Barr & Birke, 1998; Barton, 1998; Eisenhart & Finkel, 1998) . This paper reflects on what a gendered experience with school science means for these preservice teachers, both in terms of opportunities granted and opportunities foreclosed.

I situate this work in what Angela Barton (1998) refers to as the third wave of feminism in science and science education. Feminist theory in this "wave" provides a "refreshing lens from which to reflect on the inclusiveness in science education" (Barton, 1997, p. 146). That is, the questions that I ask here originate from a self-reflexive interest in my own practice as a teacher educator, and they are explicitly political— I am concerned with helping to create a more equitable science education, both for the preservice teachers that I work with and all of the students that they will eventually work with. That is, I am experimenting with enacting a feminist liberatory science education (Barton, 1997). This "wave" of feminist theorizing and praxis compels me to acknowledge both the socially situated nature of science, and school science in particular, and the socially situated nature of the teachers and students that interact [or refuse to interact] with this science. To this end, I hoped to educate teachers who would, "help students create new and different representations of science that are inclusive of students' entire lives," and who would,

"help them interrogate and politicize the intersections of and contradictions between their lives and traditional representations of science" (Barton, 1998, p. 18).

Identity as [shifting] meaning-maker

This research draws on a sociohistorical conception of identity. Contrary to essentialist notions of a unified and coherent identity, this perspective sees, "identification as a construction, a process never completed— always 'in process'. It is not determined in the sense that it can always be 'won' or 'lost', sustained or abandoned" (Hall, 1996, p. 2). But this notion of identity as constantly in flux is not a collapse into relativism, and should not be read as putting identity categories under erasure. Instead, "what this decentering requires....is not an abandonment or abolition of 'the subject' but a reconceptualization— thinking it within its new, displaced, or decentered position within the paradigm" (p. 2). So rather than being a settled, stable, essentialist conception, what I am forwarding here is the notion of an identity as positional and strategic— "identities are about questions of using the resources of history, language and culture in the process of becoming rather than being: not 'who are we' or 'where we came from', so much as what we might become, how we have been represented and how that bears on how we might represent ourselves" (p. 4).

Rather than being individualistic constructions, identities are constructed in specific cultural, historical, and institutional sites. As subjects (rather than objects) we "are shaped by the way in which we are 'interpellated' by the discourse habits of others, that is by the assumptions about what it is to be a person that are projected onto us as we participate in social interaction with others in our community" (Lemke, 1995, p. 14). Identities always form in relation to others and in this way are positional.

Identities are "constructed through, not outside, difference" and "within, not outside, discourse" (Hall, 1996, p. 4). I want to use these notions to disrupt what I see as the laziness around issues of men and masculinities and science. By this I mean the totalizing discourses that homogenize men and women in different ways, and place them all as central in positions of

power, or as on the margins in powerless positions, respectively. Not only are such views over-simplistic, but they do an injustice to all who are marginalized and silenced by science as we know it because they present an inaccurate and incomplete picture. The issues are much more complex then that. As such , identities are fragmented and fractured, "never singular, but multiply constructed across different, often intersecting and antagonistic discourses, practices and positions" (p. 4).

What follows from such a definition of identities, I believe, is the necessity for a more nuanced portrayal of gender— from a relatively dichotomous category that gets seamlessly juxtaposed on "biological sex", to a shifting construct informed by sex, ethnicity, sexual orientation, social class, "race", ablebodiness, parental status, and a myriad of other identity categories. To resist the narrowness of a "sex belies gender" conceptualization and to open up the possibility for a more accurate and critical representation of what contributes to and sustains one's gender, I argue for this broader definition. While this may seem to make 'gender' an unwieldy construct, I would argue that previous notions were sanitized and barren, and that if a multitude of factors do interact to form a gender identity, then as difficult as it might be, we as researchers are obligated to work within this more holistic representation. By way of disclaimer, however, this is not to imply that this desire is fully actualized in this study. The ability to successfully operate from this new standpoint will not come easily. Still, what I have attempted to do is to frame my exploration in these more realistic terms.

What I find particularly fruitful to think about in relation to autobiographical writing and identity is that identities,

> arise from the narrativization of the self, but the necessarily fictional nature of this process in no way undermines its discursive, material or political effectivity, even if the belongingness, the 'suturing into the story' through which identities arise is, partly, in the imaginary (as well as the symbolic) and therefore always, partly constructed in fantasy, or at least within a fantasmatic field (Hall, 1996, p. 4).

This view completely eliminates the "are they telling the truth" binds that many have caught themselves up in. Instead, it allows me to accept their "stories" as vehicles for their identities, as informative. And I chose this narrative mode of expression as a core component of a course in which I hoped to interrogate my own identity as well as the nature of science as the students did the same, "because the narrative mode leads to conclusions not about certainties in an aboriginal world, but about the varying perspectives that can be constructed to make experience comprehensible" (Bruner, 1986, p. 37).

The study

This study differs from past work with autobiographical writings[1] in that it looks at the ways in which identities are asserted and explained in light of past experiences with science and in light of future plans to be an elementary teacher who will [most likely] teach science. I am interested how these students use their past experiences to theorize about their future practice, and so the site of my investigation is the students' "identities in action" as articulated through their writings. My interest in this paper is to look at three students' "identities that school science inspires" (Eisenhart, Finkel, & Marion, 1996, p. 278) as embedded in a sociohistorical framework, focusing on the social situatedness of identity and its historical antecedents, both within the individual's life history and in a larger societal sense. I want to examine the ways in which gendered relations and experiences with school science *constitute* these students' identities, rather than just inform them. Instead of just reading that the nature of science is implicated in marginalizing certain groups from science, for instance, the intent in this course was to show how experiences with science constitute marginalization and alienation, with the ultimate goal being the theorization of solutions to these problems. This theorization took the form, most explicitly, of a philosophy of elementary science teaching.

To this end I ask the following research questions: In what ways are these students' identities bound to science [or not] as they prepare to teach it? How do the constructs of science

and identity mutually inform one another? And, in what ways have past experiences with science been gendered, and how do they manifest themselves in students expressed identities now?

In order to attempt to answer these questions I examined several writing pieces produced by the students as part of their elementary science methods class that I taught in the spring semester of 1997. The class had 27 students in it. For the purpose of this paper I will report the cases of three students from the class— Mario, Kiki, and Ed.

I chose narrative inquiry as my mode of investigation both because the students were writings several narrative pieces over the course of the semester, and because it allowed the students to question their own experiences and describe their own stories. This study took advantage of the fact that these students were in a unique position in their lives— they were reflecting on what it was like to be a student of science through the eyes of a prospective teacher who was still a student. Thus, these students are looking back at their world (and theorizing from it) from a space created by their contiguous, but not seamless identities.

The semester started with the production of two short 'critical incident' papers (Rosenthal, 1991) in which the students reported on two memories from their past formal or informal (out of school) science educations. The course syllabus instructed them to write about, "recollections in which you can clearly describe an experience (either positive or negative) that relates to science in an educational setting. Each paper should detail the particular memory, clearly state how science was involved, and describe how you and others (if applicable) felt about the experience."

The students then drafted their science autobiographies, referencing general guidelines that asked them to think back about both their formal and informal experiences with science. Again, the syllabus included such guiding questions as: Did you at any time consider a science related career? What past science experiences have you had that have influenced your feelings about science? Which science subjects did you like the most? Why? Which did you like the least? Why? Describe an experience that you have had where you believe that you have really understood a scientific idea. Why were you able to grasp this idea so clearly?

In addition to these written source materials, the students also wrote about what their

metaphor for their role as a teacher was, participated in a whole-class discussion about the metaphors, and then had a chance to revise their metaphors. In the last week of the course, after they had taught for five days in their cooperating teacher's classroom for intensive week, they were asked to reflect in writing about how well their metaphor matched with their teaching practice while they were in the schools, and to write a teaching report describing how their "intensive week" of teaching had been.

The last two written pieces comprised their take-home final exam. The first question asked them to start to articulate their philosophy of elementary science teaching. After starting this piece with reference to two autobiographical reflections, the students were to address their views about what science is, their views about what school science is, their views of how to teach science, and how science relates to the rest of the curriculum. They were required to cite at least eight of the written works that we had read as a class during the course of the semester, and to quote directly from at least four of the works. Finally, the assignment read, "This paper is an opportunity for you to demonstrate how you envision the theory that we talked about all semester in this class translating into practice. Be adventuresome and playful. Have fun with this!"

The other question on the final exam asked them to:

> Choose the single most memorable autobiographical experience that you've written about this semester (in either a critical incident paper or your science autobiography) and write a counternarrative to it. Counternarratives are often stories that violate the "official" versions of the ways things "should" be. For example, a dominant narrative in our country is that everyone is given a chance to succeed in school (or in science), but a counternarrative would be a story that illustrates that this claim is not entirely true- not **everyone** has the same opportunities to succeed in school (or in science). After you write out your counternarrative, briefly describe (in a couple of paragraphs) what you could learn from the counternarrative that you couldn't have learned (or never would have thought about /noticed) from your original autobiographical narrative. (EDDV 341 course syllabus, 1997).

The intent with this question was to have their own story serve as a basis for a counternarrative (Giroux, Lankshear, McLaren, & Peters, 1996) to the hegemonic interrelationships between science, gender, and schooling, and to allow them to think about what new could be seen by creating and interpreting the counternarrative. One of my goals in assigning this question was to have students read their identities "against the grain" (Hall, 1996) in order in envision their experiences differently.

In this paper I explore data collected in an elementary science methods class to describe a variety of ways in which students' make sense of science via their past experiences. My intent is not to derive a normative taxonomy of the ways in which these young people see science and their identities as connected [or disconnected], but rather highlight the variety of ways in which these issues interconnect in students' lives and in their visions of teaching science.

Taken collectively, these assignments marked my attempt to help these students to "come to know science" (Cavazos, Bianchini, & Helms, 1998) through reflection on their own experiences and in anticipation of the teaching careers that were ahead of them. I also hoped to have them experience "theory as a liberatory practice" (hooks, 1994) as they theorized from their reflections on past science experiences. Rather then handing the theory to them via a lecture or assigned readings, I thought the theory should originate from analysis of our collective reflections. Because much of our collective work in class originated form these writings, I was intent on creating science out of critical examinations of personal experiences (Osborne & Barton, 1998), and explicitly examining the ways in which our reflections on our experiences enabled this to occur.

Mario: I see myself as a coach on a baseball team

Mario is an elementary and special education major, with a subject specialization in math. His expectation for the methods course was to, "get some idea of how to teach science to children." At the beginning of the methods course he wrote that he decided to become an elementary teacher education major because, "I had several positive teaching experiences throughout high school." He elaborated on this in his science autobiography.

> When it came time for me to choose a career, teaching seemed to be the only option for me. Science never seriously factored into that decision. It was based on previous experience with teaching young children religious education. I never saw myself concentrating on a single subject for the rest of my life. I enjoyed all of the subjects in school too much to focus on just one. It occurred to me that an elementary school teacher had to be knowledgeable in all of the subjects in order to be any good. So it was my love for science as well as for math and social studies, but not so much English, that drew me to a teaching career [SA][ii].

In his first critical incidents paper Mario described his participation in a "science in a shoebox" program, an "informal" science education experience he had one summer when he was eight or nine. The program, which entailed gathering and examining specimens from the beach, river, forest, and field, "offered me the opportunity to explore and discover science for my self rather than simply having it taught to me by another person. As a prospective teacher reflecting on that experience I realize that it is because I was able to guide my own learning that what I learned became so meaningful" [P]. "It made science fun for me because everything that we discussed, we also saw and touched" [SA]. This memory seems to involve a touch of a 'rugged individualism'—to really learn science one must explore and discover for one's self. It's not clear how "guiding" one's own learning is different from learning on one's own. In addition to this, Mario really seems to favor sensory, empirical experiences over all else. So not only was he 'going it alone', but he needed to collect, see, touch, and examine the objects to maximize his learning.

His second critical incidents paper involved a memory from seventh grade. As part of an assigned project, he and a partner raised and studied an anole lizard for the semester. At the end of the project, each team wrote a report "including all of the data collected over the term" and then "a long, long summary of the data" [C2]. They received a C- on their report, but never got it back to see "what we did wrong." Mario reflected, "Apparently I learned very little from an entire semester of work, and I couldn't even learn from my mistakes." He concludes, "this is an example of a project that started out to be excellent and was ruined by an incompetent teacher" [C2]. In his science autobiography Mario again comments on this situation, noting, "The report went well,

however the experience was ruined by the teacher reading our grades out loud in front of the class and then not letting us even see what we did wrong. The rest of the year didn't go very well either" [SA]. Here Mario reflects on the [sometimes] authoritarian nature of school science, as illustrated by the behavior of his teacher. Not only were their grades announced publicly, but they never had the chance to see where they made mistakes.

In his science autobiography he writes that, "All through my childhood I was particularly fond of science as a subject.....Science never really seemed hard for me, at least not in elementary and middle school. The material was never presented in as much of a hands-on manner as "science in a shoebox," but I still enjoyed it" [SA]. His first memory of school science was in the fourth grade.

> I had my first male teacher that year and his specialty area was science. Among other things I remember the class working together to build a hot air balloon out of tissue paper. We measured each piece and cut it carefully. Then we glued the pieces together in the shape of a balloon.....I do remember how incredible it felt to see the balloon take off into the air.
>
> That year was a big year for me because I met my first male teacher. Until then I thought that only women could be a teacher in elementary school. I thought that he was the coolest guy that I'd ever met because he had an earring and drove a motorcycle to school. Now I don't know if his motorcycle or earring had anything to do with why I decided to become a teacher or even why I enjoyed his class but it definitely caught my attention. On a side note, I recently went back old elementary school and saw him again— he had stopped riding his motorcycle and had white hair, although he still wore and earring. He remembered my name [SA].

This well articulated by Mario. Scant attention is paid to the ways that elementary teaching is gendered, particularly in the context of discussions about science. But Mario identifies an experience that really had an impact on him. It is such a unique situation because it occurs at the intersection of the feminization of elementary school teaching and the masculinization of science— a male elementary science teacher, definitely an anomaly. And not only was he a man, but he was cool!

In high school, "for some reason I could never figure out anything ever taught in chemistry. The entire subject eluded me and continues to this very day. In fact, chemistry is the only science that I haven't taken at the college level. Maybe I'm trying to deny it exists by avoiding it" [SA]. Biology was no better for Mario— "When I was learning about biology from a "shoebox" I loved it, but Bio class was a bore." [SA]. He continues to write,

> My senior year I made up for the previous two when I took physics. I enjoyed physics very much. I particularly enjoyed working with lenses and mirrors....I can not attribute my opposite reactions between chemistry and physics to the teacher because I had the same teacher for both classes. I discovered through the years that I am a mathematically-oriented person which explains why I enjoy physics and not biology [SA].

Mario exhibits two interesting trends as he moves through school. First, science seems to get less interesting for him as he moves up in grade level, and second, he really enjoyed physics but really did not connect with either biology or chemistry.

Not surprisingly, given his taste for the empirical, when Mario defines science and school science, he focuses on the empirical aspects of each. On his mid-term exam, Mario wrote, "Science is a process in which we learn, not an end result." He continued,

> In the article about the "sinkers and floaters" [Konicek, King, & Teece, 1990] the students learned that science is a compromise made in order to define things. By that I mean that people must agree on limits and definitions in order to achieve results. By doing this science becomes an ever-changing study, growing with the discoveries made. Science becomes more about people working in order to learn. To me the difference between science and school science is only that science is the pursuit of new knowledge while school science is the pursuit of realizing how to learn [E].

This article, which Mario cites above as part of his mid-term exam, really seems to add support to his already blossoming sense that the best science is empirical science- stuff that the kids can experience for themselves. It is not clear form this passage whether the "people working in order to learn" are doing so together or by themselves.

On the final exam, part of which consisted of starting to articulate a philosophy of science education, Mario seemed to have developed his conception of science.

> The word science brings to mind many different images of futuristic labs and chemicals. This is the image of science that has been created by cartoons. Other people think of science as an encyclopedia full of facts and information about the world to be learned. I feel that both of those images of science are correct, but in a very limiting way. True, there are facts that are known about the world and chemical labs with crazy looking scientists all as a result of science, but there is a greater definition of science. "Science is more than a collection of laws, a catalogue of unrelated facts. It is a creation of the human mind with its freely invented ideas and concepts" (Einstein, 1938 in Howe & Jones, 1993, p. 7). Science is the process of humans discovering things that they didn't know before. Not just scientist humans, but every human uses science to figure out as much as they can about the world that they are living in. Science is an active, changing thing not an old list of information [P].

Mario cites two stereotypical, but culturally pervasive, views about what science is— cartoon images or encyclopedic catalogues. These are both very gendered images of a detached, impersonal way of knowing. Mario's definition tries to humanize these extremes a bit by introducing people back into the process.

This vision of school science is codified on the final exam when Mario reflects on the counternarrative that he wrote to the "science in a shoebox" experience he had. In this scenario, the instructor just lectured the kids about each object. "He would stand in front of the class and tell us about what the environments of the artifacts were like....We never got to see any of these animals discard their shells, but we heard about how it happened. At the end of the summer he took the artifacts out of the shoe box one at a time, and we had to write everything that we knew about them on a piece of paper. I never did worse on a test because I couldn't remember anything about any of the artifacts" [CN]. In reflecting on this tale, Mario wrote, "I see that children can't be expected to learn from simply being told information. Of course this essay was a ridiculous example of bad learning, but it did make me realize that there is no other way for a student to learn than to see things for themselves. If a child can learn on their own then they are more likely to remember what

they learned as I did' [CN]. What this counternarrative seems to have accomplished, which was not at all what I might have hoped as the course instructor, was to reinforce the notion that science is an activity involving both rugged individualism, a classic liberal virtue, and a reliance on what can be directly experienced, a naive empiricism.

After completing "intensive week," a week out teaching in a school, Mario wrote in his teaching report,

> I feel that what I experienced in the classroom is entirely separate from anything that I have read in any of my classes. I feel a total separation between the theories that we read about and the actual experiences of teaching. Very little of what I have read prepared me for what I saw in the classroom. I feel that by spending more time in the classrooms and less time on theories would produce better, more prepared teachers [TR].

The above statements were written in one of the last assignments that Mario turned in for this class. They are interesting on a number of levels because he seems to be asserting the necessity of the same empirical criteria for the preparation of teachers that he does for the teaching/learning of science. It's not enough to hear about or talk about something, one must experience it. While at some level this seems to be a rather benign, if not a worthy aim, it becomes a troubling standard for all instruction because it is both laced with anti-intellectualism, and it works to ignore that not all of science [nor of teacher education] can, or even should, be experienced first-hand. Although it seems consistent with his views of science "as the process of humans discovering things" [P], it is a narrow take on what science and science education in their totality entail, and it points towards the need to more explicitly recognize these issues and address them in class discussion.

Referring to the recent work of Helms & Carlone (1999), Mario seems to dwell with these authors' first formulation of the commonplaces of science— "Science is an activity in which evidence is gathered through observation and experiment to explain and predict natural phenomena" (p. 236). While the utility of these commonplaces is that there are many ways to interpret them, it seems that Mario is taking a literal, macroscopic interpretation with as little mediation as possible getting in the way of observing natural phenomena. As the authors note,

such a formulation is problematic and limiting because, "it may not take into account what counts as evidence, what is observed, what explanations are constructed or what predictions ensue are dependent upon theoretical commitments" (p. 237). Perhaps some more explicit unpacking of these two criteria for the ways in which they are gendered and foster a gendered view of science would have been helpful during the class for Mario and other students who found themselves with similar definitions of science.

Kiki: My students are half-full boxes of prior knowledge and I will build on that prior knowledge and continue filling the box with valuable information

An elementary and special education major with a subject specialization in English, Kiki hoped "this class will help me feel more comfortable with the teaching of science in elementary schools." She has "always liked to be around children and it makes me feel satisfied when I know that I have taught or helped a child learn something new." Besides, she has "always wanted to be a teacher." From the start we can already see the ways in which a gendered identity is expressing itself in relation to the teaching of children.

She has studied physical science, biology, and geology in college, and of the three, "I have had the greatest interest for biology.....biology topics can hold my interest because I feel that the information is useful" [SA]. This is in stark contrast to her experience in physical science— "I found the material covered in the class to be very boring and the way the professor tried to teach the material did not help [lectured with his back to the class, endless formulas and problems on the board, no time for questions]" [SA]. Again, this connection to content that seems to best link to their worlds is a common experience for students in science, especially when engagement in science is going to entail some border-crossing (Costa, 1995).

"Science," Kiki writes, "more than any other discipline, provides us with tools to learn about the world. Science is not a listing of facts; science is an invitation to observe the world, ask questions, and puzzle over problems and enjoy the process of solving them" [P]. Because science "touches every aspect of their lives," school science is an essential component of the curriculum for

children. She goes on to note that, "My views of school science is [sic] based on the assumption that learning science in a classroom setting is a function of the nature of the student, the nature of science, the instructional strategy, and the expected outcomes" [P].

In her first critical incidents paper Kiki recalls one of her worst science memories—dissecting a fetal pig in tenth grade.

> I was taking general Biology with Mrs. Anderson. To begin with, science is not one of my favorite subjects. In fact, it became my least favorite subject when Mrs. Anderson announced that my class would be dissecting a fetal pig during the next few weeks.....I did not see the purpose of dissecting an unborn pig. Mrs. Anderson thought it was necessary to understand the human body.....I have a high respect for animals and believe that they should not be dissected for any reason. The only an animal should be dissected is for medical purposes. I have and had no desire to know what the inside of a fetal pig looks like. For this reason alone was a waste of a pig because neither myself nor Mrs. Anderson benefited from this activity.....Thank God my partner looked forward to dissecting the pig. The look sand smell did not bother him at all. Biology was interesting to him and he was interested in knowing what the inside of a fetal pig looked like. Plus, I think he enjoyed trying to gross me out. He did not mind doing most of the dissecting, which was a relief to me.....I felt like a good pig had gone to waste for my sake....Mrs. Anderson wanted the dissecting of the pig to be an unforgettable experience. It did leave an impression on me, unfortunately it was a negative one [C1].

This experience illustrates the case when "science is another world" (Costa, 1995) for Kiki because she feels so alienated by it. She fails to even have grasped the rationale, or at least refuses to accept it as valid, and this moves her further into disengagement.

In critical incidents paper two Kiki tried to focus on a positive memory of science. She wrote,

> It is hard for me to remember a very good experience in science that had an impact on me. My science classes always seemed to be very repetitious. Every day was the same old thing. We would learn new vocabulary words, read from the text, and answer questions at the end of the chapter. BORING! I think all of the teachers in my elementary school, starting in the first grade and continuing in to eighth grade,

> had the same method of teaching.....The only time I can actually remember enjoying science is when my third grade teacher had a student teacher in our classroom. The student teacher's name was Ms. Stover (I think). Ms. Stover was there to teach us about the solar system. At first this did not interest me in the least because science never interested me. After the first day Ms. Stover had my attention because she took a different approach to science....She made science interesting for the short time that she was there. She allowed us to work in groups, read together with partners, draw what we thought outer space looked like, and read fiction books about space....It was so "cool" because Ms. Stover decorated our classroom like outer space....I believe Ms. Stover may have inspired me to be a teacher. If you were to ask me who was my favorite teacher I would definitely say Ms. Stover. If you were to ask me why she was my favorite teacher, I would say because of the way she taught....Once I decided to pursue a career in elementary education I knew that I would want to be the type of teacher that Ms. Stover was and probably still is.

Here Kiki really focus on the pedagogical aspects of science, noting the myriad of ways in which they failed to engage her or many of her classmates. These issues are foregrounded when she has a student teacher who recreates the whole way of "doing science" in her third grade classroom. What are most salient here, I believe, are the pedagogical changes that Ms. Stover made that seem to have enraptured the students. Her initial lack of interest in the solar system, a topic that seemed boring, was quite quickly dissipated once different teaching methods and material were employed. While it might be a stretch to argue that Kiki's case illustrates that good teaching can even make 'boring' content fun to learn, her case may serve to caution us not to over-rely on what are perceived to be masculinist or androcentric units of content curriculum, for perhaps the content alone can't readily make or break a lesson. Content and pedagogy need to be viewed collectively and as interacting. These points are further reinforced below.

Kiki was asked to reflect more generally on her experiences with science in her science autobiography. She noted that, "Science is a difficult subject for me. I believe this is because of the way I have always been taught science." [SA]. She had few memories of hands-on science from

her high school years, and even fewer from her elementary years, admitting, "My teachers have always been very traditional." [SA]. She continues,

> My experience with science began to change when I took college level science courses. I began my hands-on experience at this time because laboratory was required. I did not enjoy this because I felt uncomfortable at times because of my lack of prior knowledge. At this point in my life I knew I wanted to be a teacher, so I knew I had to start taking science seriously....They [college professors] never gave me the feeling that they thought science was exciting, so why would I ever want to learn it?.....I hate that I have felt this way about science. I do have to admit, however, that as I get closer to becoming a teacher, my interest in science is growing. I know that I need a solid background in science before I can feel comfortable teaching this subject to eager students [SA].

Kiki started taking science seriously, even though her past experiences with science may have given her little reason to feel this way, because this would be necessary if she were to become a teacher. Although she has never felt positive about science before for any sustained period of time, and had hated to have felt this way about science, she knows that it is a prerequisite for a career in teaching. Besides, as she gets closer to becoming a teacher, her "interest in science is growing"[SA].

Kiki decided to write her counternarrative about her tenth grade dissection experience. She constructed this fictive scenario as "one of her favorite memories in science"— the chance to dissect a fetal pig! She continues,

> Science is my favorite subject and I looked forward to the next few weeks of General Biology....I was one of the many students in science class that saw the necessity of dissecting a fetal pig....I, along with many other students, knew this would be a valuable hands-on experience that we would never forget. The dissecting day came upon me and I approached the dissection with curiosity and excitement. I was being given the chance to explore the "human body" in a safe and comfortable environment.....This experiment was useful and interesting....Once we began the dissecting of the pig my partner was not much help to me. He had what you could call a "weak stomach"....He was getting up and leaving the classroom every few minutes to avoid getting sick. He did not want to help with the

> dissecting. I had to do the majority of the dissecting, bit I did not mind because I found it to be very interesting and educational....During the dissection of the fetal; pig I learned a great deal of information about the human body. Thanks to this wonderful hands-on experience I am able to take this valuable information with me into the elementary classroom [CN].

Although one lesson that could be drawn from re-creating this memory could be that dissection was not so bad after all and contained some valuable lessons, Kiki concluded something quite different from it. She wrote, "In writing this counternarrative I see what I lacked when doing the actual dissection of the fetal pig was confidence and prior knowledge. My biology teacher did not prepare me for my experience with dissecting; she simply announced that we would be dissecting a pig....I feel that I missed out on what could have been a valuable experience if Mrs. Anderson would of approached it correctly' [CN]. She does note that her over all mood in this fictional passage was one of enthusiasm, which she acknowledges is very important in the classroom. But she does not continue to question the validity of such an activity, one that involved the taking of an unborn animals' life. Instead, she focuses on why she was under-prepared and what could have happened that would have rectified this situation. Although I was not hoping for any particular outcome from students when they wrote their counternarratives, I confess that I am saddened that instead of formulating a stronger case to object to the class dissection, Kiki seems [in my eyes] to have acquiesced, looking for a deficit in herself to explain her lack of engagement rather then a deficit in the pedagogical and curricular practice. Consistent with her 'revelation' about being under-prepared she writes, "I have now realized that I must always prepare my students to the fullest and make them feel safe and comfortable in my science classroom" [CN].

Kiki started her philosophy of elementary science teaching by disclosing,

> My recollection of elementary science is very vague. This vague recollection leads me to believe that I have always had a dislike for science. I do not think my dislike stems from the topics, rather the way the topics were taught.. When I formally encountered science my teachers were very traditional. The class read from science textbooks, took paper and pencil tests, and never did any hands-on activities. This was "boring" and I developed a great dislike for the subject. It became my most

> dreaded subject because I saw it as a unless, uninteresting subject. Fortunately, my college level courses have allowed me to experience positive encounters with science.....I now have a much needed respect and understanding of the nature of science. I hope with the years to come that my knowledge will continue to grow so that my students will benefit from my teaching of science. I plan to take my positive experiences and use these to become the best science teacher I can be [P].

This reflection about a school career of taking science is fascinating in light of the dissection counternarrative because Kiki now frames her woes in science as problems with 'delivery' rather than content. This troubles me some because although she may well have had years and years of bad teaching, this contention could also be borne of an attempt to locate her disengagement with science in a personal lack— I was under-prepared, I was under-stimulated, I was under-challenged— rather than as something possibly inherent in the content of science as it was being presented to her. I don't refute the power of good teaching that her reflection about Ms. Stover illustrates, but I am concerned if students' first reaction when they are not engaged with something at school is to look inward for blame. Even though Kiki doesn't seem to have any trouble identifying her teachers as the source for lack of engagement, I think that what she may ultimately be referencing is a personal deficit model.

She continues her philosophy by noting some tenets of science teaching that she hopes to enact when she is a teacher. These include: "Science should be taught to help students develop an understanding of how science relates to everyday life", "School science should develop and build on students' natural curiosity about the world around them", "Students will develop inquiry and process skills required for problem solving in all areas of life with a proper science education", and "I will teach science to provide opportunities for students of varying interests and ability levels to experience success" [P]. Many of these tenets of her philosophy seem to be counternarratives to many of her own experiences that she has described above. That is, even though she has had a lifetime of not so positive to clearly negative experiences with science, from her own experience and what she believes to be best for children she can construct an alternative vision of what science teaching could be, a "possible world" of science— in which she is an integral and active player!

Ed: I see myself as a nanny, much in the likeness of Mary Poppins

Ed is an elementary education major with a subject concentration in social studies. He expects that the course will teach him how to teach science. He decided on this major because, "I like to work with kids" and it "sounds like fun." In his science autobiography, he reflected about choosing to become a teacher, writing "I think I chose it more because other people said I would be good at it rather than I had any real desire to do it....People always told me I was a good listener...Also, I always liked little kids better than people my own age, so the logical combination of these two ideas was becoming a teacher" [SA].

Ed saw science as "doing experiments, finding possible solutions to problems, building on previous knowledge to build understanding, asking questions." He later wrote, "Science, as defined by Howe & Jones (1993) in chapter 1, is both a process and knowledge. This means that science is not only the answers but how we get to them as well' [E]. He differentiates science from school science by writing, "School science deviates from science in the idea that school science does not deal as much with theory than it does with putting science in a context where students can see science working in everyday life" [E]. In his philosophy of science teaching, articulated near the end of the course, Ed defined science as "basically just problem solving" [P]. He continued.

> A person dealing with just science is trying to figure out how things work and why things are the way they are. They do this through observation and experimentation, by testing hypotheses, and by getting others to repeat their experiments to see if they get the same answers. Science is a very impersonal field where those involved have very small contact with those outside a lab. Even when there is outside contact it is usually with other scientists [P].

I find this final definition of science to be very striking, if not disturbing! Taking a more micro-view than Mario did, Ed makes explicit the lack of a social milieu surrounding the practice of science. His take on Helms & Carlone's (1999) first formulation of the commonplaces of science would surely be read quite narrowly, more so I think than Marion would read it.

Ed contrasts this image of science with school science, noting that the science taught in schools "has some of the same points as science in general but has a more personal feel to it" [P]. Writing that both content and processes are important in the science curriculum, Ed cautions, "If you attempt to throw terms, numbers, and formulas at elementary students, you are going to turn them off science faster than a plate of spinach. Be that the case, school science has to be made more relevant for the students to learn" [P].

He noted that his favorite science subject was biology, because it's "light in math," it deals with living plants and animals, and he has always done well in it. His least favorite science, because of the emphasis on math, is physics. In his science autobiography, he notes that "science is a subject that I have always gotten some enjoyment out of studying. It was only when math was needed in great quantities that I lost interest in science" [SA].

In his first critical incidents paper, Ed described "one of the earliest memories I have of science in school," an eighth grade Jeopardy-style quiz show in class. Each student supplied answers to which the contestants had to supply the correct questions. Ed recalls,

> One of the reasons this experience was memorable was the fact that I actually came up with the question that Mr. Bass [the teacher] couldn't even answer. I actually had to show him where I got the question from in the textbook. Also it was one of the first experiences I had where science was actually fun . Up till this point, science was just another class during a boring day at school....[Mr. Bass] used his own real life experiences to make the class fun. He also showed real world connections to what we were learning to show that science really was used outside of school. Mr. Bass is probably one of the first people that turned me towards wanting to be a teacher [C1].

Stumping the teacher, that is challenging the authority in school, or school science, was a highlight for Ed. He also appreciated, as we saw in Kiki's writings earlier, when his teachers, in this case Mr. Bass connected the content of science to the students' lives.

Ed tried to write about a bad memory of science in his second critical incidents paper because the first one was a bout a good memory.

> The only one I can think of is my 12th grade physics class in general. There are a few reasons I see this class as a bad experience. One is the fact that I don't remember all but one thing that was taught in the class. The one thing I do remember is shooting pencils at a paper monkey. We were supposed to learn something about gravity or something I think. Also, the fact that I have no real love for math at high levels and I saw this class as a second high level math class for the year didn't help any either.....The class was one of the ones we had to go to but definitely didn't like doing it. Most of the people in the class spent most of the time day dreaming or passing notes [C2].

In his science autobiography Ed was able to reflect about science over the course of his schooling. He gleaned,

> Science is one of those subjects that I loved in elementary and middle school, but in high school and college, science was a chore or a course that I had to take to graduate. It's a shame that it has to be like that since I seem to have a good mind for science ideas and theories. As for experiences that have influenced my feelings about science, there isn't much more to tell other than what I wrote in my two critical incidents papers [SA].

Ed experienced almost the opposite trend that Kiki did in terms of waxing/waning engagement in science as he moved through school. Whereas Kiki has only recently garnered an interest in science, due in no small part, most likely, to its necessity for her to get certified as an elementary school teacher, Ed seems to have lost the joy that he once felt for science. It is now a requirement, or a hurdle to be jumped. Ed notes that this situation is "a shame," but it persists.

Ed wrote his counternarrative about his experience in 12th grade physics, which he detailed in his second critical incidents paper. He ventures,

> Physics was the best class of my high school career. It is amazing how one course can help a person decide what they are going to do with their lives. This physics class has helped me decide to go on in college to get a degree in teaching high school science. The experiments and lessons were very well formed and challenging. The information learned in that class has helped me through my entire college career. This is one class that I will always be grateful to have taken.

Making sense of writing this counternarrative Ed notes that it, "has helped point out how one event can help shape a person's life. It shows me as a teacher that I have to give all students the opportunity to do what they wish. This is because if I fail to give a student the chance to try it may change their life forever." Like Kiki, Ed's focus is on the teaching rather than the applicability or appropriateness of the content involved in the physics course. He also sees value in writing the counternarrative because it has helped him realize that not all people see a situation the same way—"while I may see some management issues from one perspective because I am the teacher, students will see the same situation from another perspective. That is why writing this counternarrative is a good and important idea" [P].

When detailing his philosophy of elementary science teaching, Ed wrote that "the main points of my view hinge on the relationship between student and teacher, as well as the idea that the students are capable and should be expected to help the class by sharing their thoughts and ideas, even if they differ from my own as the teacher' [P]. He highlighted such important factors as, "School science is also about the environment the students are learning in. If the students don't feel safe in the classroom, any attempt at learning is going to have luke-warm results at best." He continued,

> I have discovered over intensive week that I do much better when I know the students and am able to have a good dialogue with them.....Another key part to my philosophy is to make sure that all students in my class have the same opportunity to learn to the best of their ability. Just as the title of the Hampton and Gallegos (1994) article suggests, science needs to be for all students.....Another piece of my philosophy deals with students understanding what they are doing and why. To do this I, as a teacher, need to keep my ears open to the students' questions and to what they are saying to one another.....So as I have been saying, my philosophy deals mostly with communication between my students and myself and how well we teach each other [P].

Ed's focus on the importance of the teaching is clearly reflected in his philosophy of science teaching, one which emphasizes communication between the teacher and students. But

rather than positioning the teacher in an authoritarian stance, Ed adopts a much more democratic vision, hoping that he and his students can engage safely and respectfully in deep dialogue.

Ed wanted to explain his choice of the nanny metaphor "since this sounds strange coming from a guy." He wrote, "I see myself as a person who has a lot to offer my students, wants to have their respect, but also wants to help them have a fun time while they're at it. Hence the idea of Mary Poppins." After teaching during intensive week he still thought this was an apt metaphor. After intensive week, Ed wrote, "It is hard to get a feel for elementary science when you are a college student. Now that I've seen science taught in a real elementary school I think I have a better feel for what will and will not work for me once I get a classroom of my own" [TR]. Ed's choice of metaphor is interesting not only because of its highly gendered nature, but also because it further emphasizes the role of the pedagogy, rather than the content, in the act that is science teaching. This seems quite consistent with both his earlier reflections and his explicitly stated philosophy of science teaching.

Discussion

Results from an analysis of these three students' writings illustrate the incredible range of ways that school science was experienced in a gendered manner, and the ways in which these experiences shape these preservice teachers' orientations towards school science as they contemplate teaching. Although we can notice some overlapping, such as the affinity that both Kiki and Ed seem to have for the pedagogy over the content, I think the three cases are more distinct than alike. This is not surprising given that what we are looking at are the ways in which these students draw on and negotiate past experiences with science as they articulate identities as future science teachers. Their writings suggest the powerful effects that past science experiences have on their on-going construction of science teaching identities. Further, their writings recognize the complex ways in which the constructs of schooling, gender, and science interact, hybridize, and experience synergy or attrition as they collide with one another. These constructs do not always meet up with one another neatly- an example being Kiki's less than positive experiences all

through school science and the sudden realization that she must complete science courses to be certified to teach elementary school- something she has wanted to do all of her life. This work also allows us to view the spaces where the commingling of these three factors— schooling, gender, and science—gets articulated through preservice teachers autobiographical recollections. For instance, we see a nice example of this co-mingling as Ed explains his metaphor of teacher as nanny.

I think that even three case studies from a class of 27 students shows how complex and nuanced students' "identities that school science inspires" (Eisenhart *et al.*, 1996) can be. I think it would be interesting to start to investigate how these preservice students erect boundaries to demarcate what science is, what influences the erecting of those boundaries, and what functions those specific boundaries serve. That is, what ends are their own definitions of science serving? What do they gain or lose by espousing, and enacting, (a) certain version(s) of science. As preservice teachers, what do they have invested in certain views of science? Of school science?

In an attempt to link the students' experiences with the vast literature base about gender and science, and in the hopes that they would be able to theorize from their own articulated and analyzed experiences, I embarked on this journey with autobiographical writing in my science methods class. Although it was clear time after time that the students were not necessarily learning what I "hoped" they would learn or even what I thought they were learning, they certainly were engaged. Their reflections and resultant philosophies of elementary science teaching convince me that they were deeply engaged, if not variably so, with the intersection of issues of science, gender, and identity.

But this does not alleviate me from addressing the obvious issues related to my practice as a methods class instructor. What else can be done to help students not only articulate past experiences but to explicitly theorize from an analysis of those experiences about what they would like science to be and what they would like their future classrooms to be. This is a story with many loose ends and what some might argue is a very untidy ending, but where is it getting us that we were not going before? As preservice teachers preparing to teach science, among several other

subjects, how can we make more explicit the embededness of the gendered nature of science as we advocate that "science is good to think with" (Harding, 1996)? These are curricular and pedagogical challenges that lie ahead.

While I think its important for students to envision "possible selves" they would like to be or "possible worlds" they would like to help create, I also acknowledge that these students' visions were borne out almost solely in written philosophies [with a little bit of practicum during intensive week] and are therefore as yet untested in classrooms. So it is imaginable that they will not be able to or even want to enact all that they have envisioned in their teaching philosophies. Rather than speculate and despair at potential goals unattained, however, I focus on the success of having the students not only think deeply about these issues, but also to explicitly articulate them, holding them up for inspection, for revision, and as goals in their process of becoming.

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[i] I discuss this body of work in more detail, highlighting both benefits to using an autobiographical technique as well as some shortcomings, in Letts (1997).

[ii] The following symbols after data refer to the assignments from which the quotes were taken: E refers to the mid-term exam, P refers to the philosophy of science teaching, CN refers to the counternarrative, C1 and C2 refer to critical incidents papers 1 and 2 respectively, SA refers to the science autobiography, and TR refers to teaching report.